

Divisional of 09/991,702

AMENDMENTS TO THE SPECIFICATION

Please replace the paragraph on page 1, beginning with line 11 and ending with line 16, with the following rewritten paragraph:

This application is a divisional application of 09/991,702, filed November 26, 2001; which is ~~This application is~~ a Continuation-in-Part of pending application Serial No. 09/412,610 filed October 6, 1999 (now U.S. patent no. 6,342,110), which is a Continuation-in Part of application Serial No. 08/977,518 filed November 24, 1997, which is a Continuation-in-Part of application Serial No. 08/835,926 filed April 8, 1997 (abandoned), which is a Continuation of application Serial No. 08/609,327 filed March 1, 1996 (abandoned).

Please replace the paragraph beginning on page 5, beginning at line 24 and ending on page 5, line 30, with the following rewritten paragraph:

It is an object of this invention to provide a method for making current collectors from lead and lead-alloyed with at least one element selected from the group of Ag, Al, As, Ba, Bi, Ca, Cd, Cu, Fe, Li, Mg, Na, Se, Sb, Sn, Sr, and Zn utilizing gravity or continuous casting; casting a billet followed by extrusion and/or rolling, and, if desired suitably perforating the strip e.g. by expansion or punching. In its final form the current collector can be a bookmold grid, a tubular grid, a foil or sheet, a perforated strip, i.e. suitably punched or expanded, a continuous cast grid or a continuous cast grid which is subsequently rolled to its final dimension.

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Please replace the paragraph beginning on page 19, at line 22 and ending on page 19, line 24, with the following rewritten paragraph:

The treatment time varies, depending on the material, but typically ranges from 1 ~~seconds~~ second to three days, more typically from 5 seconds to 12 hours, and preferably from 10 seconds to 3 hours.

Please replace the paragraph beginning on page 20, at line 19, and ending on page 20, line 30, with the following rewritten paragraph:

To measure the samples resistance to strain deformation, which is directly related to positive current collector growth in a lead-acid battery, standard ASTM E139 creep tests were performed. Each sample was subjected to a ~~strain~~ stress of 4.8 MPa over a period of several hours at room temperature. The amount of deformation, in millimetres, was then plotted as a function of time. The results are summarised in Figure 3. The rate of strain deformation over time for the as cast material was calculated as 1150% per year. By comparison, the rate of strain deformation for the grain boundary engineered material was found to be only 35% per year. The grain boundary engineered material processed by the embodiments of the present invention showed greatly increased resistance to strain deformation. It should be noted that this result cannot be attributed to precipitation effects as outlined in the work of Tilman and Myers as the commercially pure lead does not contain any precipitate forming elements, and further underscores the novelty of this present invention.

Please replace the paragraph on page 21, beginning at line 14 and ending on page 21, line 19, with the following rewritten paragraph:

A Pb-0.073wt% ~~Ca-0.07wt%~~ Ca-0.7 wt% Sn alloy (Class II) was processed by three cycles each comprised of cold rolling at room temperature to achieve a 40% reduction in thickness, annealing at 270 °C for 10 minutes in air followed by air cooling. The resulting microstructural improvement in terms of special grain boundary content is summarized in Figure 5 (identified as PbCaSn in Figure 5). The special grain boundary content was increased from 11% in the as-cast starting material, to 51% in the material processed by the method described.

The paragraph on page 21, beginning at line 21 and ending on page 21, line 26, was amended as follows:

A Pb-0.065wt% ~~Ca-0.07wt%~~ Ca-0.7 wt% Sn 0.03wt% Ag alloy (Class II) was processed by two cycles each comprised of cold rolling at room temperature to achieve a 40% reduction in thickness, annealing at 250 °C for 10 minutes in air followed by air cooling. The resulting microstructural improvement in terms of special grain boundary content is summarized in Figure 5 (identified as PbCaSnAg in Figure 5). The special grain boundary content was increased from 12% in the as-cast starting material, to 70% in the material processed by the method described.

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Please replace the paragraph on page 23, beginning with the term "Example #4" at line 17 and ending on page 23, line 30 with the following rewritten paragraph:

EXAMPLE #4

Various lead alloys were subjected to ~~the~~ one or more deformation and annealing ~~cycle~~ cycles used to make the recrystallized lead-alloy according to this invention. ~~Each of the samples~~ In each cycle the sample was deformed at room temperature to 25% reduction in thickness and then annealed by heat-treating at 255°C for five minutes. After the final first deformation reduction and annealing, each of the aforementioned lead alloys was tested for hardness. A minimum of six hardness measurements at each of two locations of the test alloys were obtained using a Shimadzu model HMV2000 micro hardness tester utilizing a 25g load. The hardness of each metal was also measured in the same way in the as-cast condition (i.e. without being subjected to deformation and annealing cycle). The f_{sp} count of the as-cast material samples prior to GBE processing in all cases was between 10 and 15%. The results of the hardness test for each of the lead alloys is shown in Table 2. In all instances, the deformation reduction and heat annealing ~~cycle~~ cycle(s) resulted in an alloy having a lower hardness than the one of the corresponding as-cast alloy.

Please replace the paragraph on page 29, beginning with the term "Example #10" at line 5 and ending on page 29, line 14, with the following rewritten paragraph:

EXAMPLE #10

A set of Pb-Ca-Sn-alloy bookmould cast grids was surface peened at room temperature for 10 seconds, followed by heat treatment (275°C, 10 minutes).

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Careful analysis of grid cross sections revealed that the penetration depth achieved extended up to 350 micron below the peened surface and that the grain size in the near surface layer was 10 micron, while it remained at about 260 micron in the bulk material. The surface layer of the peened and annealed sample had a f_{sp} of 40%, whereas the untreated sample f_{sp} and the f_{sp} of the treated material more than 350 microns below the surface remained at 15% (table 8).

[[f_{sp}]]

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Please replace the paragraph on page 30, beginning with the term "Example #11" at line 9 and ending on page 30, line 17, with the following rewritten paragraph:

EXAMPLE #11:

Two Pb-Ca-Sn alloys were cast into sheets. An as received set representing prior art and a set processed according to the invention were corrosion tested in an environment representative of a zinc-electrowinning operation. The peening was performed using 28 mil steel shot at 80 psi at room temperature. Three passes per substrate were performed within three minutes and the peened samples were subsequently annealed at 250°C for 10 minutes. A pretreatment comprising a 30 minute soak at 300°C was used to modify existing precipitates to facilitate the GBE process. The following ~~table illustrates~~ tables 9 and 10 illustrate the sample characteristics and the corrosion performance.